High resolution industry modeling using HYCOM

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LONG TERM GOALS

To develop an industry modeling capability for deep water and continential shelf areas using very high resolution nested versions of HYCOM.

To develop a global operational ocean montoring and prediction system using state of the art numerical model tools and data assimilation methodologies.

To integrate these capabilities to establish a forecasting capability for nested regional model domains which can be used to support off shore industry operating along and off the continental shelf.

OBJECTIVES

The Hybrid Coordinate Ocean Model (HYCOM) is currently being devloped by by scientists at the University in Miami, the Naval Research Lab in Stennis and Los Alamos National Laboratory (http://hycom.rsmas.miami.edu/). At NERSC we presently consider this model to be "the model for the future" and we are now using the model in several applications related to operational oceanography.

The purpose of this effort was to visit some of the labs involved in the HYCOM developments and operational oceanography within the US NAVY, to:

1. Communicate personal experiences with the HYCOM model in high resolution coastal shelf simulations carried out for off shore industry.
2. Become updated on the technical development and status of the HYCOM model and establish a better interaction with the scientists involved in developing the HYCOM code.
3. Discuss progress and future perspectives within operational oceanography.

[1] The Nansen Environmental and Remote Sensing Center (NERSC) is a non-profit research institute affiliated with the University in Bergen, Norway.

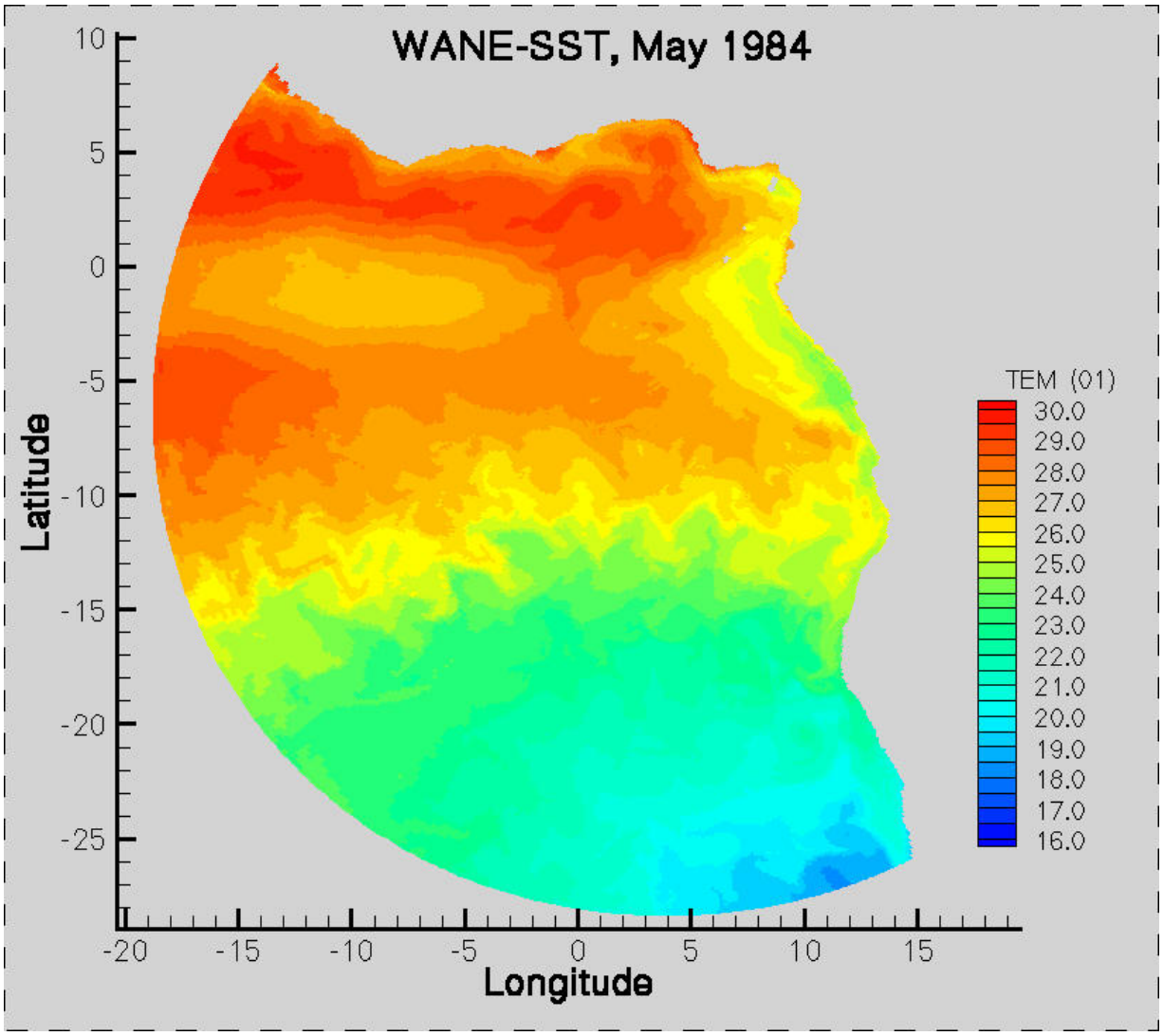

Figure 1: The plot shows sea surface temperature from the regional model domain used in the WANE project.

APPROACH

During the previous 4–5 years NERSC has been involved in oceanongraphic modeling studies for off shore oil industry. Initially we used the Miami Isopycnic Coordinate Ocean Model (MICOM) developed by Bleck et al., (1992) at the University of Miami, but MICOM is now replaced with HYCOM to better resolve vertical velocity shears in the surface mixed layer and to better represent the transition from the deep ocean to the continential shelves which is made possible with the new hybrid coordinate.

This activity has involved a number of projects. Currently we are executing two projects to support deep water drilling, one off the West African coast (WANE) and another project covering the Faroe Shetland Channel (NWAG project). The purposes of both these projects are to:

1. establish a model system which is capable of representing water mass characteristics during long time integrations;

2. calibrate the model system to also provide current variability in good agreement with observed currents;

3. use the model results to enhance our understanding of the regional oceanography;

4. during a long multiyear simulation, store time series of currents which can be used to compute current statistics needed for derivation of design criteria.

Obviously these applications are extremely demanding on the ocean model used. The area of interest is often located along the continential shelf break and is therfore dependent both on processes on the continental shelf and in the deep ocean off the shelf. These regions are normally dominated by steep bathymetry, strong tidal waves, shelf waves and strong currents. In the Faroe Shetland Channel we also have to discriminate between the very cold bottom water and the warm saline Atlantic water in the upper few hundred meters of the water column.

To have a realistic model system it is necessary to use large scale basin models to get the general transport of water masses right. The approach we have taken is to nest high resolution regional models into the large scale models. This provides a possibility to use a very high resolution model in the main area of interest. In NWAG which is at about 59 North we are using an inner model with 2 km resolution, while for the WANE project which covers the area from 25 South to 5 North we are currently using 5 km resolution. The regional model used in the WANE project is shown in Figure 1.

The model system has been calibrated towards a large number of current meter data to provide current variability in agreement with observations. The model is now being run in a production simulation to produce hindcast current statistics which will be used to support the estimation of design criteria for offshore oil installations operating in deep waters. This activity has been the first where HYCOM has been used for such high resolution modeling, with tides, and focusing on regions which contain both deep waters and the transition onto the continental shelf.

This industry modeling activity has now been organized under a new company, Ocean Numerics Ltd., formed by the Nansen Environmental and Remote Sensing Center, Norway, and Fugro GEOS Ltd[2], UK. It builds on the strengths of the parent companies to provide regional meteorological and oceanographic ('metocean') studies throughout the world's oceans. Ocean Numerics provides a single source for integrated regional metocean studies and operational forecasts for both engineering and environmental applications to the offshore and marine industries. These services will use advanced numerical models and forecasting techniques, validated and tested with oceanographic field measurements that have been designed and collected specifically for this purpose. For the first time this wide range of experience, skills and services will be available commercially from one source.

The long term strategy of the company is to develop and operate a global ocean prediction system, and to support the offshore industries with tailored forecasts for selected areas. The global operational model will be developed with strong links to, and a two-way interaction and exchange with, the international scientific community. The funding for the operation of the system will be based on the operation of an arbitrary number of regional nested models which are used to provide paying customers with tailored products.

[2] Fugro GEOS is a specialist consultancy with over 20 years experience in the provision of metocean data collection, analysis, interpretation and forecasting services for offshore and coastal engineering applications. It operates on a world-wide basis with offices in the United Kingdom, the United States, Australia, Abu Dhabi, Singapore, Malaysia and, through the offices of the Fugro group, in more than 40 other countries.

TRAVEL COMPLETED

The visit at the different institutions was hosted by the persons listed in the table below. However, I am greatful for the hospitality and the time allocated by a large number of staff with whome we had discussions on different scientific and operational aspects.

Table 1. Summary of visits conducted under this VSP

Person visited	Position	Institution	Location	Purpose	Dates
Alan Wallcraft	Dr.	NRL	Stennis	HYCOM model, data assimilation	31/01-01 to 02/02-01
Rainer Bleck	Prof.	LANL	Los Alamos	HYCOM model, data assimilation	03/02-01 to 06/02-01
Andrew Bennett	Prof.	NRL	Monterey	HYCOM model, data assimilation	07/02-01 to 10/02-01

RESULTS

The main results from the visit can be devided into two categories: the first related to the further development of the HYCOM code, which is now maintained by Alan Wallcraft at NRL–Stennis. We provided him with our version of the code to allow him to merge the two versions together and take advantage of some of the developments made at NERSC. During the last few years we have developed a number of additional modules which are coupled to HYCOM. If these are integrated into the public version of the model, this will also make it easiar for us to adapt new releases of the code, and everyone should benefit from this. Additional technical discussions on the HYCOM code were organized with Rainer Bleck at LANL, and in particular related to the further strategy for parallelization of the code.

We had interesting discussions with staff from NAVOCEANO at Stennis and FNMOC in Monterey, in particular related to how NERSC could be involved in particular projects and possibly provide services in cases where we already have a regional model system established for a certain area and data are needed quickly.

We also used the opportunity to explore possible collaboration in an ONR proposal on uncertainty which was recently submitted by NERSC. If this proposal gets funded, this will trigger an extensive collaboration between NERSC and the NRLs.

IMPACT/APPLICATIONS

This effort has strengthened the communication and interaction between the US groups and NERSC related to the further HYCOM development and transition into operational systems. Further, is seems like NRL and NERSC have similar goals related to the use of HYCOM for regional high resolution applications, while the HYCOM community in general is more focused on the basin or global scale or even climate. This is a strong motivation to developing joint projects in the future.

TRANSITIONS

There is an obvious potential for technology transfer related to particular modules in the HYCOM model system as discussed above. E.g., for the time being the public version of the code does not have a complete ice model, a routine for the computation of surface fluxes and the possibility for using tidal boundary conditions. Further interaction between NERSC and the HYCOM team will ensure that these modules are implemented in the public releases of HYCOM.

RELATED PROJECTS

NWAG: North Western Approaches Group. High resolution current modeling for the Faroe Shetland Channel.

WANE: West African Normals and Extremes. A recently started project redoing the previous WAX simulation made with MICOM, using a higher resolution version of HYCOM and a longer 15 years hindcast.

TOPAZ (EC Framework Program V: Extension of the DIADEM forecasting system, which now displays real time ocean forecasts for the Atlantic on the web

http://diadem.halo.is/diadem/rtweb.html,

to use the HYCOM model and down-scaling to coastal zones by introducing nested sub domains. The purpose is to developing a real time forecasting capability for regional high resolution areas in support to off-shore oil industry.

NOPP: US initiative for developing operational modeling and data assimilation.

REFERENCES

Bleck, R., C. Rooth, D. Hu, and L.T. Smith, Salinity-driven thermohaline transients in a wind- and thermohaline-forced isopycnic coordinate model of the North Atlantic, J.Phys. Oceanogr., 22, 1486–1515, 1992.